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LAMB MORTALITY IN A COMMERCIAL LOWLAND SHEEP FLOCK

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Summary

Meteorological observations were made on a lowland farm between 1976 and 1979 with a view to studying the influences of weather on lamb mortality. The studies indicate that the incidence of field deaths of young lambs tends to be related to the weather 'stress' experienced over the previous 24 hours and show some interesting features of the 'exposure' of the pastures.

Introduction

'.....there is hardly an expense equal to the effects, both to fields and livestock, of a gnawing or destroying air'

Bain (Quart. Journ. Agric. 1839)

Farm livestock can be affected by climate both indirectly, through the influence of climate upon the availability of food, and directly as a result of exposure to the rigours of climate (eg Blaxter 1962, Obst and Ellis 1977). The rate of metabolic heat production in homeothermic animals such as lambs increases in response to an increase in heat loss to the environment and represents an attempt to stabilize body temperature. Heat loss increases as environmental temperature falls and as air movement and/or evaporation from the coat increase.

The environment becomes potentially lethal for the lamb when the heat loss from the lamb exceeds its 'summit metabolism' - the maximum rate of heat production that the lamb can summon.

Clearly the total environmental effect experienced by a lamb will fluctuate from hour to hour and follow variations in air motion, temperature, radiative effects and the intensity and duration of the rainfall, as has been demonstrated, for example, by Slee (1977) in measurements of the (electrical) energy required to maintain the temperature of a simulated animal, by Alexander (1964) in climate chamber research, and by Sykes et al (1976) in field observations. Such investigations indicate that almost all new-born lambs are subject to cold stress (and a high metabolic demand) which is compounded by low body (energy) reserves with which to meet the demand.
An erosion of energy reserves from an already undernourished or sick lamb, particularly in breeds with short birthcoats, is recognised as contributing to the incidence of death in young lambs. In severe climates associated for example with hill farms, coldstress might be the primary cause of death in new-born lambs.

Such weakling stock might be at risk even in apparently moderate weather conditions such as those generally encountered in SE England; it is this hypothesis that is investigated in this paper.

Materials and methods

Ewes and their lambs were allocated to fields on a south-facing, undulating slope of the Berkshire Downs leading down to the River Pang (fig 1). The establishment and disposition of an instrument network was guided by the limitations imposed by the numbers and nature of the instruments available, by review, after on-site inspection of the minimum of monitoring stations necessary to draw out local 'climate' differences and by the availability of staff. In all four years all fields where lambs were allocated were instrumented.

'Run-of-wind' measuring equipment (cup anemometers) exposed at 2 m height, and minimum thermometers at 1 m were established near feed and watering areas and near significant hollows. Surveys with hand-held anemometers helped to establish a preliminary view of the association between local land form and local wind speed and direction. A chain of minimum thermometers was also established to monitor conditions within, and in the vicinity of, the ewe housing. Data were related to a 'reference' site established in Annis field (fig 1) which housed a raingauge, run-of-wind anemometer, grass minimum thermometer, maximum and minimum thermometers and a thermograph housed in a Stevenson screen at lamb height and a minimum thermometer, screened simply and exposed at 1 m as in the other fields. During the critical neo-natal period daily readings were made. Subsequently, in 1978 and 79, continuous meterological recordings were made at lamb height with automatic equipment. The representativness of such 'fixed point' data in the present context may be open to question. The data can only provide an approximation to the actual environment experienced by a lamb capable of seeking shelter and within a protective flock. However, such data, even if not correct on an absolute scale, still provide a means of estimating days of relatively high or low environmental stress.

Data by Alexander (1964) provided the basis for expressing the environmental variables in terms of heat loss elicited from the young lamb. From fig 1 of Alexander it may be deduced, for example, that the heat loss (M) from a young, dry 2 kg lamb with a fine coat in still air at -32°C ($\bar{M}$ = 186 K Cal $m^{-2}hr^{-1}$) is the same as that from the lamb, with a dry coat in a 5.5 ms $^{-1}$ (12 mph) wind and at an air temperature -4°C, or, with a wet coat in a 5.5 ms $^{-1}$ wind when the air temperature is +13°C. The influence of wind and particularly a wet birth coat are clear. Although this work was on young Merino lambs, the results were taken as applicable to the Bradfield lamb stock, a not unreasonable assumption according to Alexander (Private Communication).

In 1978 the environmental heat demand of the environment over four-hourly periods was estimated as multiples of the basal metabolic rate M_B, from the observed combination of wind, temperature and rainfall (it being assumed that rainfall wetted the coat instantly and that the cessation of rain similarly marked the return of the birthcoat to the dry state). The heat loss estimates were accumulated for one, two and three days prior to lamb death and tabulated against the total numbers of lamb field deaths occurring within equal increments of the cumulative energy demand $\bar{M}$. If the 'observed' deaths are not weather related, every day would hold an equal probability for the death of lambs. $\bar{M}$ was therefore calculated for every day and deaths allocated in proportion to the number of days with a given range of energy demand to give an 'expected' death distribution. Since the dead lambs were only recovered once daily in 1978 the 'time of death' is in question; the assumption was made that all lamb deaths occurred about midnight - some 8 hours before the bodies were retrieved. In 1979 hourly estimates of the heat demands were made - and lambs were recovered twice daily - although deaths occurred predominantly overnight.

Results

Bradfield weather for the four years is now briefly described; mortality will then be discussed.

1976

After a mild, dry winter, the spring and summer of 1976 continued to give exceptionally low rainfall. Less than 50% of average rainfall fell in March and May; April and June had only 25% of average. At Bradfield there were only 14 days with rain between mid-March and the end of May and only 8 had more than 0.5 mm. Strong westerly winds set in for two weeks at the end of March followed, in the second half of April, by a spell of northerly winds. Temperatures were somewhat below average in March and April, but well above average in May and June.

1977

Air and earth temperatures were well above average from February until mid-March.

A cold spell then set in until early April (encouraging extended stays in the housing for lambs born then). Late April produced strong, wet westerly winds which slackened off during the first half of May. A dry northerly wind became established until early June. In the mid-March to end of May period there were 43 days with rain at Bradfield of which 37 had rainfall of more than 0.5 mm.

1978

The mild spell at the end of February continued into the first week of March, under the influence of fresh to strong south-easterly winds.

In mid-March, after a wet night on 15/16, the temperature dropped sharply in a cold north-westerly air-stream and a belt of snow affected the area, followed by wintry showers until the 17th.

North-westerly gales occurred on the 20th and winds continued fresh to strong until the 29th.

Summary for March: windy and unsettled; Temperatures mostly above normal but wintry at times.

The first four days of April were dull and misty with rain or drizzle. A sunny north-easterly spell set in on the 4th; early on the 10th a very cold northerly air stream arrived after a cold front crossed the area and a wintry spell followed, with overnight frosts and moderate snow.

Summary for April: (coldest since 1956) cold, north-easterly winds predominated. Mostly cold or very cold, with wintry conditions during the second week.

May started wet and cool but the second half was dry, sunny and very warm.

1979 (graphical summary - Fig 2)

March

A wet westerly airstream affected most of the country for the first part of the month. It became colder from the 13th with snow or sleet showers or rain widespread for the rest of the month and strong winds at the end of the month.

Mean temperatures were below average, rainfall (including water equivalent of melted snow) was twice average.

April

Generally unsettled and cold for the first 12 days with fog patches on 3 consecutive nights from the 3rd.

Easter (13th to 17th) was the warmest since 1949. Thereafter the weather was again unsettled. Mean temperatures below average with rainfall nearly twice average.

May

Unsettled and cool with rain and sleet in the first week becoming dry and warm by the 12th and very warm on 14th and 15th. Then it continued unsettled.

Summary

This was the coldest spring since 1962, the wettest since 1947 (and the second wettest this century).

In 1976 only 6 field deaths accredited to 'stress' occurred - they were of twins in Rushall field, perhaps justifying the high exposure rating deduced for this field (see Discussion of pasture exposure studies). In 1977 rain and wind-run were only recorded at 24 hour intervals, and rainfall and winds over shorter periods allocated on the basis of continuous records from Benson (20 km to the north)- these data qualitatively indicated the tendency for increased death incidence to be associated with days posing the higher environmental stress. It is the detailed data for 1978 and 1979 which form the basis of the Results. In 1978 the mortality incidence was studied for the March period alone (when the majority of lambs dying were under 10 days old) and for the remaining period to early May (when age at death was in the range of 20 to 60 days). A similar analysis was made in 1979.
The Kolmogorov-Smirnov test (a test not limited by small samples) was used to test for significant differences between 'observed' lamb field deaths (ie deaths not ascribed to organic disease) and the 'expected' deaths in 1978 (The null hypothesis tested was that there was no difference between the two distributions).
The difference between observed and expected mortality in 1978 in lambs less than 10 days old is significant at the 7% level when 'stress' is accumulated over 1 day; there is no significant difference between distributions when either stress is accumulated over several days or as lambs get older.

Discussion

Table 1 summarises information on 1978 'field losses' gained by the Veterinary Investigation Unit, MAFF, Reading. Noteworthy features of the table are:-

i. field deaths dominated by twins and triplets.

ii. negative (or only small positive) weight gains generally recorded in lamb deaths where the animal is under 10 days old.

iii. mortality not confined predominantly to any one field.

It is of interest to study the energy considerations of lamb survival. Alexander (1964) states that 'summit metabolism' in young Merinos is a out 50 K cal hr^{-1} (3 Kg lamb) or about 200 K cal m^{-2} hr^{-1} (ie about 4 times basal metabolic rate M_B). In the present study, the maximum hourly energy demand was estimated to be 4.4 M_B and the corresponding demand over a day to be 89 M_B. Experimental figures from the Bradfield study indicate environmental demands which, over the day, are close to 'summit' demand and which exceed this demand over short periods (No young lamb succumbed if the cumulative daily demand was below 60 M_B). Total useful energy reserves in lambs from adequately fed ewes are about 259 K cal Kg^{-1} (ie 750 K cals for a 3 Kg lamb); the time to exhaust fat and glycogen reserves is hence of the order of 15 hours. Eales (1979), further points out that twins, each weighing 3 kg, have something like 30% more surface area through which heat is lost than a single 6 kg lamb; in addition the twins have to compete for the available milk supply.

The low, generally negative, liveweight gains in the young lambs (table 1) points to the energy intake being unable to match the energy loss to the environment; this continual erosion of energy, even if not fatal, is reflected on low liveweight gain and hence in the sale weight of the fat lamb.

The Bradfield lambs were housed during the critical first day and overall were subjected to an altogether more moderate climate than that which can cause problems to upland flocks. Nevertheless the 1978 Bradfield data indicate that there is a difference between observed and expected young lambs mortality. The implication is that young lambs (particularly twins or triplets), less than say 10 days old, can be at risk even in quite moderate weather.

The enforced use of shelter by ewes and lambs has been noted (Egan et al 1972) to be a major contributory factor in reducing neo-natal lamb deaths; indeed Cresswell and Thomson (1964) found that even the small amount of shelter from wind afforded by 'tussocky' pasture could be important for lambs.

In 1979 the severe March weather made the farm manager decide against putting the lambs out between 14/22 and 24/26 March; 185 were put out in Back Lane on 13th and a further 288 on 23rd. Many lambs were, thus, between 2 and 10 days old when first exposed to climatic rigours.

Fig 2 records the influence of the severe weather during three periods in mid and late March and early April. The significant difference between observed and expected mortality in young lambs (<10 days) within three equal 'daily heat demand' categories is displayed in tables 2a; 2b, the corresponding table for older lambs (dying after 7 April) reflects no such significant difference (as in 1978).

Table 2 Expected (e) and observed (o) lamb mortality as a function of environmental heat demand on the day of death (expressed as a multiple of the basal metabolic rate, M_B)

a) 8 March - 6 April

xM_B	54-66	66-78	78-90
e	27	7	12
o	11	6	29

($P \simeq 0.001$)

b) 7 April - 14 May

xM_B	40-54	54-68	68-82
e	9	18	3
o	9	16	5

No significant difference between distributions

Peak hourly and daily heat demands eg 13/14, 16, 28/29 March were in excess of the 'summit' metabolic rates for the corresponding periods and were in excess of 1978 values as well as persisting longer (for more than 36 hours on some occasions).

Table 2a shows that the relationship between field mortality of young (<10 days) lambs and weather stress was highly significant in 1979. Field mortality in <u>day-old</u> lambs commenced when heat demand over 24 hours exceeded $80xM_B$; on one night, 13/14 March, 6 of the 14 (ie 43%) 'light' lambs (<3 kg) died; only 6 out of 51 'medium' lambs (3 to 5 kg) died. None of the 4 'heavies' (>5 kg) succumbed.

Taking the total mortality in day-old lambs over the eight 24 hour periods with $\bar{M} \gtrless 80M_B$ we find the mortality of light, medium and heavy lambs to be 14.5, 5.2 and nil (expressed as percentages of their respective populations of 48, 171 and 35).

The practical implications of the critical 24 hours heat demand of 80 M_B mentioned for day-old lambs may, by reference to Alexanders fig 1, be summarised as follows: wet lambs may be in danger in winds of about 10 mph even at a temperature of about +20°C; the corresponding 'danger' temperature for dry lambs under these windy conditions is 0°C. Even a wind of below 5 mph can cause problems to wet lambs when the temperature is below 10°C; the temperature must be below - 10°C if dry lambs are to be hazarded in tranquil conditions. (Calculations show that this 24 hour heat demand of 80 M_B was attained on at least 15 occasions in Northern England and the Borders in March and April 1979).

Discussion of pasture exposure studies

It was Gloyne's (1963) conviction that, given a sufficiency of frequent data, it should be possible to infer the basic features of at least the wind régime at any site after periods of study reckoned in weeks rather than years; this philosophy was adopted in the Bradfield 'exposure' assessment. The wind exposure table, relative to Annis field is presented in Table 3; the influence of topography and tree configuration can be clearly seen. For example: a westerly flow is channelled into the low-lying, tree-lined hollow site (K) in Annis field; under a westerly flow wind speeds at site K are some 20% more than at the reference site H 16 m higher. The north/south orientated hollow in Rushall field channels a southerly flow to site R; the highly exposed nature of the feed area in Rushall Site (M) is apparent (winds from the SW up to 200% of those at the reference site) as is the lack of shelter from the NE and SE in Back Lane (T). Although Annis Cross 2 site S is situated on a ridge and some 30 m higher than the Rushall feed area, it presents a comparatively sheltered area for most wind directions. Influences of various features of the landscape on airflow have been remarked on by Gloyne (1976), Hogg (1964-65) and others.

Minimum temperature data showed the marked severity of 'frost hollows' in Rushall and Bayleys Dene compared with other sites (both generally to 2 to 3°C colder on calm, frosty ('radiation') nights).

The available data suggest, therefore, that Rushall field and Back Lane present a considerable exposure hazard for livestock and that the potentially weakest lambs should be placed for example in Annis Cross 2.

The gradation of minimum temperatures on 'radiation' nights illustrates that drainage of cold air occurs down the south facing slope (of about 1 in 7) towards the ewe housing. Minimum temperatures within the housing were about 1°C higher than outside irrespective of the presence of the ewes.

Summary

Data show that substantial variations in wind speed (and frost potential) can occur even between one field and the next; higher ground is not necessarily more 'exposed', nor low lying areas more sheltered. Above all the survey demonstrates the potential of assessing the 'exposure' of pastures. Agriculturalists could use such data in choosing feeding sites, in allocating weakling stock and, in longer term, in assessing the need for establishing shelter belts.

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Any comments or suggestions on this paper should be referred to the author.

Meteorological Office
MAFF, Reading

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Legend

Figures

1. Sketch Map of Bradfield Farm:

   Instrument sites are lettered A,E,G,H,J,K,L,M,N,P,Q,R,S,T - H being the reference site, denoted □, and comprising Stevenson Screen with thermograph, 'cocoa tin' and grass minimum thermometers, recording and digital cup-counters, recording and 5" rain-gauge. At other sites are: 'cocoa tin' minimum thermometers and cup-counter anemometers.

   Four contours are shown: 60, 75, 90 and 105 metres (about 200 to 350 feet)

2. Lamb field deaths in Back Lane, 1979, showing daily wind run, rainfall and heat demand. Temperature trace is drawn from daily maximum and minimum temperatures.

Tables

1 : Field losses, a summary of location, birth weights etc. (1978)

2 : Expected (e) and observed (o) lamb mortality, 1979, as a function of $\overline{M}$ (24 hours)

3 : 'Run-of-wind' at the sites illustrated in Fig 1 as a function of direction and expressed as a percentage ratio of the corresponding 'run' at the reference site H.

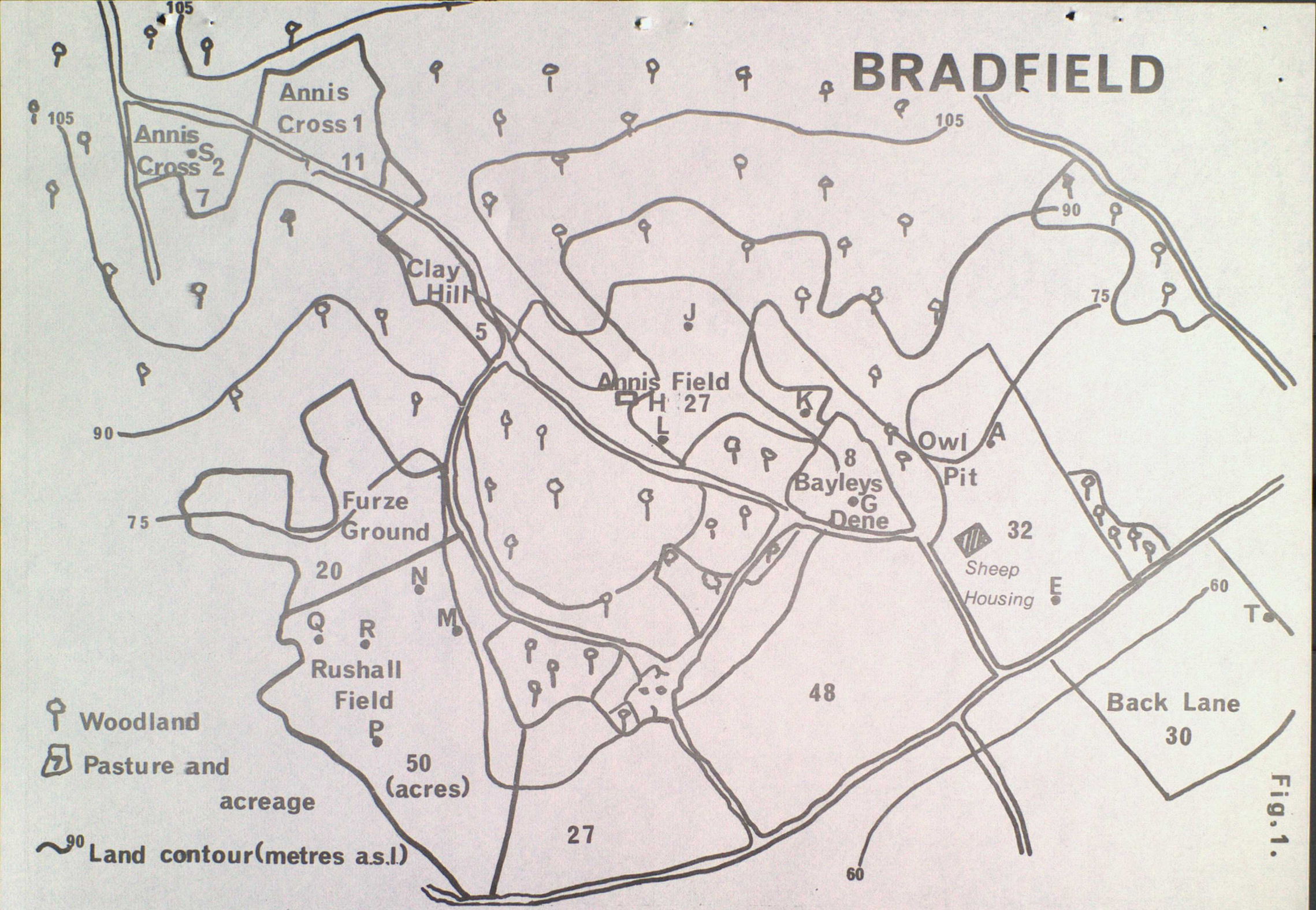
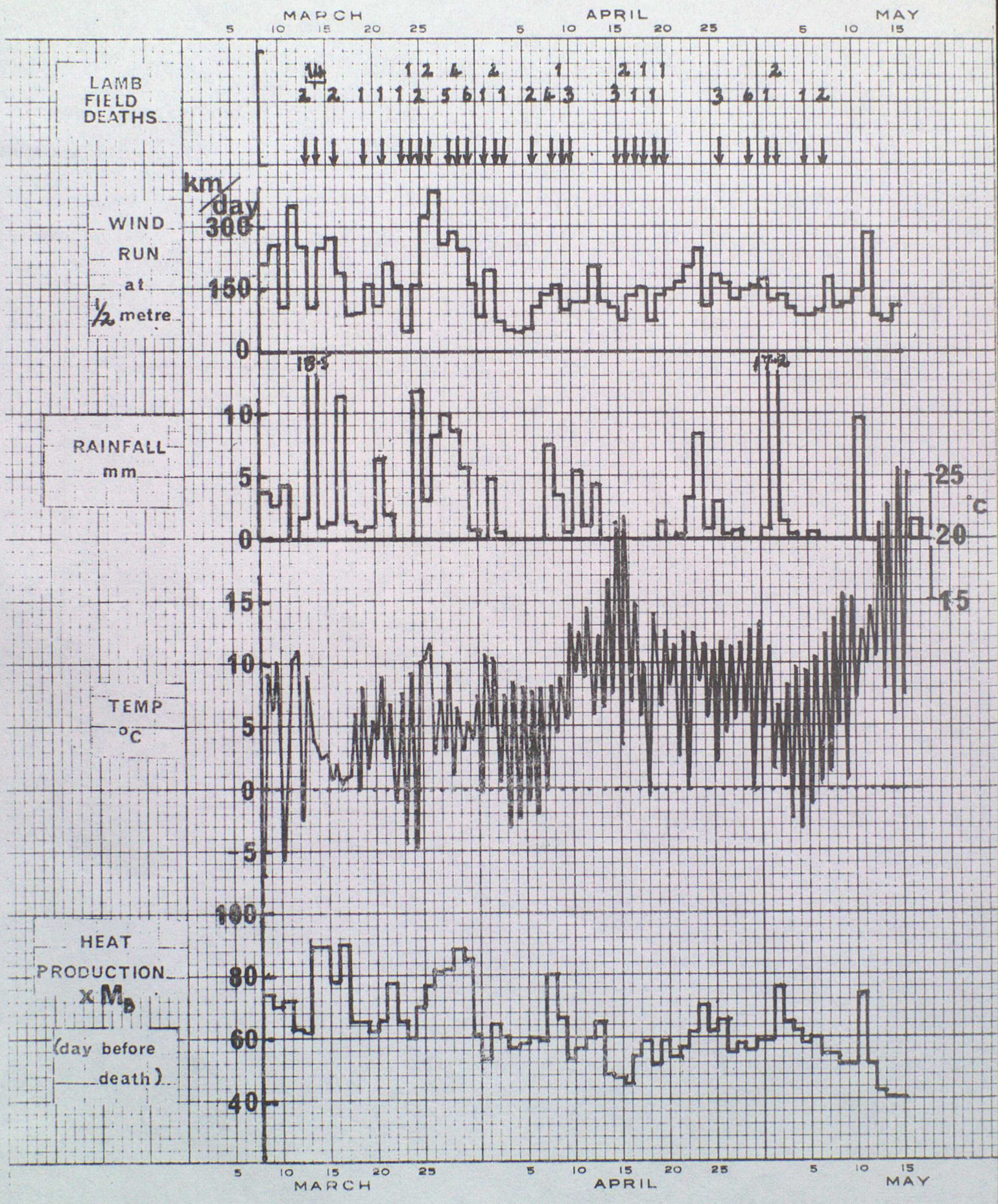

BRADFIELD
105
Annis Cross 1
Annis Cross 2
11
7
Clay Hill
5
J
90
75
Annis Field
H 27
L
K
Owl Pit
A
8
Bayleys
G
Dene
Furze Ground
20
N
M
Q
R
Rushall Field
P
50 (acres)
27
48
32
Sheep Housing
E
60
T
Back Lane
30
Woodland
Pasture and acreage
Land contour (metres a.s.l.)

Fig. 1.

1979

Fig 2


MARCH
APRIL
MAY
5 10 15 20 25 5 10 15 20 25 5 10 15
LAMB FIELD DEATHS
2 2 1 1 1 2 5 6 1 1 2 4 3 3 1 1 3 6 1 1 2
WIND RUN at ½ metre
km/day
300
150
0
RAINFALL mm
10
5
0
18·5
17·2
TEMP °C
25
20
15
10
5
0
-5
HEAT PRODUCTION x Mb (day before death)
100
80
60
40
5 10 15 20 25 5 10 15 20 25 5 10 15
MARCH
APRIL
MAY

FIELD LOSSES, BRADFIELD 1978

Table 1

Date of retrieval	Age (days)	Single (S) Twin (W) or Triplet (T)	Birth weight kg	Weight gain kg	Field
March 14	2	W	4.76	+ 0.34	A
	2	T	2.72	- 0.22	B
15	4	T	3.63	- 0.13	D
	1	W	3.18	- 0.18	B
16	5	W	5.67	- 0.47	O
	4	W	3.63	- 0.18	A
	4	T	3.97	+ 0.58	A
	2	W	4.65	- 0.12	B
18	7	T	3.29	+ 0.41	D
	2	T	3.63	- 0.03	D
19	5	W	3.86	- 0.08	B
	4	W	5.44	- 0.57	B
23	7	T	4.31	- 0.16	D
25	8	W	3.86	- 0.11	B
	7	W	4.88	- 1.03	B
	2	W	4.31	- 0.07	A
27	18	W	4.08	-	B
	9	W	3.06	-	B
	4	W	3.29	- 0.12	B
29	22	T	4.08	+ 2.08	A
	15	T	2.60	+ 0.64	D
	7	T	3.18	- 0.01	D
	7	T	2.95	- 0.05	D
	6	S	2.60	+ 0.07	O
	6	W	3.40	+ 0.24	A
	18	-	-	-	O
April 2	10	T	2.72	+ 0.39	D
	6	W	3.18	+ 0.02	A
	6	W	3.40	+ -	B
6	26	T	3.06	+ 2.18	D
7	21	W	3.63	+ 3.27	B
	15	T	3.40	+ 0.24	D
	14	W	3.40	+ 0.55	B
	3	W	5.44	+ 0.51	A
	3	W	2.95	- 0.05	B

Date of retrieval	Age (days)	Single Twin or Triplet	Birth weight kg	Weight gain kg	Field
April 10	-	-	-	--	B
	17	W	3.18	- 0.18	B
	15	T	2.83	- 0.83	A
	14	T	3.29	- 0.04	D
	6	S	3.52	- 0.32	O
14	22	W	4.54	+ 0.16	A
	14	T	2.95	+ 0.33	D
15	31	W	3.52	+ 1.22	B
	24	W	5.22	+ 0.11	B
	11	W	4.08	- 0.08	B
16	32	T	3.40	+ 1.90	D
	20	W	4.65	+ 4.55	A
19	27	T	2.49	+ 1.80	D
	25	T	3.06	+ 2.65	D
	19	T	3.86	+ 0.39	D
21	37	W	3.29	+ 6.41	B
	36	W	4.54	+ 6.96	B
	38	W	3.40	+ 0.60	D
27	36	T	6.00	- 1.28	D
	46	S	5.56	+ 4.87	O
28	49	T	6.75	- 0.67	D
May 2	28	T	4.55	+ 1.12	D
	35	T	3.62	+ 1.14	D
	39	T	2.72	+ 5.90	D
	-	-	-	-	-
8	61	T	4.08	+ 4.12	D
	47	T	2.95	+ 2.15	D
	52	S	4.76	+ 12.24	O
	34	W	4.08	+ 1.92	B
15	46	T	3.86	+ 0.49	D
	66	T	2.72	+ 4.23	D
16	-	-	-	-	-
20	71	T	4.42	+ 3.06	D

KEY

A. Annis field,
Twins (Mules + Cadzow)

B. Back Lane,
Twins (Scots Cross + ½ bred)

D. Bayleys Dene, Triplets

O. Owl pit, singles

TABLE 3

	OWL PIT		BAYLEYS	ANNIS FIELD				RUSHALL					ANNIS CROSS	BACK LANE
Direction	A	E	G	H	J	K	L	M	N	P	Q	R	S	T
N - NE	76	76	68	100	-	49	89	73	69	82	82	72	61	140
NE - E	86	83	70	100	-	53	89	74	-	91	-	80	66	170
E - SE	114	114	69	100	71	35	59	89	83	104	64	74	55	90
SE - S	121	116	120	100	68	49	61	178	160	127	90	124	75	90
S - SW	111	149	113	100	83	70	52	206	164	151	72	113	100	150
SW - W	100	170	95	100	86	91	55	175	142	147	79	93	65	170
W - NW	73	120	61	100	-	104	71	108	81	97	50	58	-	76
NW - N	72	82	58	100	-	49	87	103	83	91	60	71	-	82